The vertical structure of relative humidity and ozone in the tropical upper troposphere: Intercomparisons among in situ observations, A-Train measurements and large-scale models

Henry B. Selkirk[1], Michael Manyin[2], Anne R. Douglass, Luke Oman and Steven Pawson[3], Lesley Ott, and Craig Benson[1], and Richard Stolarski[4]

In situ measurements in the tropics have shown that in regions of active convection, relative humidity with respect to ice in the upper troposphere is typically close to saturation on average, and supersaturations greater than 20% are not uncommon. Balloon soundings with the cryogenic frost point hygrometer (CFH) at Costa Rica during northern summer, for example, show this tendency to be strongest between 11 and 15.5 km (345–360 K potential temperature, or ~250–120 hPa). This is the altitude range of deep convective detrainment. Additionally, simultaneous ozonesonde measurements show that stratospheric air (O_3>150 ppbv) can be found as low as ~14 km (350 K/150 hPa). In contrast, results from northern winter show a much drier upper troposphere and little penetration of stratospheric air below the tropopause at 17.5 km (~383 K). We show that these results are consistent with in situ measurements from the Measurement of OZone and water vapor by Airbus In-service airCraft (MOZAIC) program which samples a wider, though still limited, range of tropical locations. To generalize to the tropics as a whole, we compare our in situ results to data from two A-Train satellite instruments, the Atmospheric Infrared Sounder (AIRS) and the Microwave Limb Sounder (MLS) on the Aqua and Aura satellites respectively. Finally, we examine the vertical structure of water vapor, relative humidity and ozone in the NASA Goddard MERRA analysis, an assimilation dataset, and a new version of the GEOS CCM, a free-running chemistry-climate model. We demonstrate that conditional probability distributions of relative humidity and ozone are a sensitive diagnostic for assessing the representation of deep convection and upper troposphere/lower stratosphere mixing processes in large-scale analyses and climate models.

[1]NASA Goddard Space Flight Center, Greenbelt, MD and Goddard Earth Sciences and Technology Center, Univ. of Maryland Baltimore County, Baltimore, MD
[2]Science Systems and Applications, Inc., Lanham, MD
[3]NASA Goddard Space Flight Center, Greenbelt, MD
[4]Johns Hopkins University, Baltimore, MD

Abstract submitted to the A-Train Symposium, New Orleans, LA, 25-28 October 2010